502/228 Translation

PCT/JP2002/013165

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference TU02-1107WO1	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/JP2002/013165	International filing date (*day/month/year*) 17 December 2002 (17.12.2002)	Priority date (*day/month/year*) 13 February 2002 (13.02.2002)
International Patent Classification (IPC) or national classification and IPC C03B 15/12, C30B 29/48		
Applicant NIKKO MATERIALS CO., LTD.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 3 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
21 May 2003 (21.05.2003)	17 February 2004 (17.02.2004)
Name and mailing address of the IPEA/JP Facsimile No.	Authorized officer Telephone No.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/JP2002/013165

I. Basis of the report

1. With regard to the **elements** of the international application:*

☐ the international application as originally filed

☒ the description:

pages 1-3, 5-8, as originally filed
pages _____, filed with the demand
pages 4, filed with the letter of 04 November 2003 (04.11.2003)

☒ the claims:

pages 2, as originally filed
pages _____, as amended (together with any statement under Article 19
pages _____, filed with the demand
pages 1, 5, 7, filed with the letter of 04 November 2003 (04.11.2003)

☒ the drawings:

pages 1, 2, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

☐ the sequence listing part of the description:

pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language _____ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☒ The amendments have resulted in the cancellation of:

☐ the description, pages _____
☒ the claims, Nos. 3, 4, 6
☐ the drawings, sheets/fig _____

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rule 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/JP 02/13165

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1, 2, 5, 7	YES
	Claims		NO
Inventive step (IS)	Claims	1, 2, 5, 7	YES
	Claims		NO
Industrial applicability (IA)	Claims	1, 2, 5, 7	YES
	Claims		NO

2. Citations and explanations

Document 1: JP 61-26590 A (Sumitomo Electric Industries, Ltd.), 05 February 1986, description, page 4, upper left column, lines 16-19; page 8, upper right column, line 17 to lower right column, line 7; fig. 4

Document 2: JP 63-195188 A (Sumitomo Electric Industries, Ltd.), 12 August 1988, description, examples, fig. 1 and 2

Document 3: JP 62-288193 A (Sumitomo Electric Industries, Ltd.), 15 December 1987, fig. 1 and 3 (a)-(c)

Document 4: JP 60-27693 A (Toshiba Corp.), 12 February 1985, description, page 3, upper left column, line 13 to lower right column, line 9

Document 5: JP 7-17792 A (Sumitomo Electric Industries, Ltd.), 20 January 1995, fig. 1 and 3

Document 6: JP 1-294592 A (Sumitomo Electric Industries, Ltd.), 28 November 1989, fig. 3

Claims 1, 2, 5 and 7

The invention set forth in claims 1, 2, 5 and 7 is novel and involves an inventive step in relation to documents 1-4, which are cited in the international search

report, and documents 5 and 6, which are newly cited in the written opinion.

Documents 5 and 6 disclose the feature of growing single crystals that have a diameter equal to the diameter that is delimited by the interior walls of the inside crucible of a double crucible; however, the documents do not make disclosures in relation to the taper angle of the second crucible, the inner diameter of the communication hole or a control method for delimiting the diameters of the crystals.

Translation of Amendment under Article 34

Replacement of Page 4(Line 2 from the Bottom of Page 3 to Line 1 from the Top of Page 5)

Further, the crystal growth may be performed in a state of the second crucible being dipped in the raw material melt contained in the first crucible to a depth within a range of 10 mm to 40 mm, and a diameter of the communication hole may be not more than 1/5 of the inner diameter of the second crucible. Thereby, since it is possible to efficiently suppress temperature fluctuation in the raw material melt in the second crucible, a single crystal having excellent quality can be grown. In addition, since the communication path communicating with the first crucible is limited, even when a contaminant or the like has mixed into the raw material melt in the second crucible, it is possible to remove the contaminant from the second crucible into the first crucible by pulling up the second crucible, to thereby prevent the contaminant from being mixed into the crystal being grown.

Furthermore, although a difference in the concentration of the impurity in the raw material melt is caused between the first crucible and the second crucible when an impurity as a dopant is added to the raw material melt, it becomes possible to control the difference in the

concentration of the impurity in the melt and keep constant the concentration of the impurity in the raw material melt in the second crucible by modifying the size of the communication hole of the second crucible under the condition of the size not more than 1/5 of the inner diameter of the second crucible.

Further, a temperature gradient in the raw material melt may be set to at least not more than 20°C/cm, whereby it is possible to prevent a polycrystal or a twin crystal from occurring. It should be noted that since the growing crystal is always covered with the encapsulating material, even if the temperature gradient is reduced, there is no fear of decomposition of the growing crystal.

Brief Description of The Drawings

FIG. 1 is a view schematically showing the arrangement of a crystal growth apparatus used in an embodiment of the present invention; and

FIG. 2 is an enlarged view showing a raw material melt-containing portion of the crystal growth apparatus shown in FIG. 1.

Best Mode for Carrying Out the Invention

Hereinafter, a preferred embodiment of the present invention will be explained with reference to the drawings.

FIG. 1 is a view schematically showing the

arrangement of an embodiment of a crystal growth apparatus according to the present invention, and FIG. 2 is an enlarged view showing a raw material melt-containing portion.

The crystal growth apparatus 100 comprises a high pressure container 1, a thermal insulation member 2 and a heater 3 arranged within the high pressure container 1 concentrically with the same, a rotating shaft 4 arranged vertically in a central portion of the high pressure container 1, a susceptor 13 arranged on the upper end of the rotating shaft 4, a pBN outer crucible (first crucible) 5 having a bottom and a cylindrical shape and fitted in the susceptor, a pBN inner crucible (second crucible) 6 arranged within the outer crucible 5, and a rotating lift shaft 7 vertically arranged above the inner crucible 6 and having a seed crystal holder 8 attached to the lower end thereof, for holding a seed crystal 9.

PATENT CLAIMS

1.(Amended) A method for producing a compound semiconductor single crystal by a liquid encapsulated Czochralski method, comprising:

containing a semiconductor raw material and an encapsulating material in a raw material melt-containing portion comprising a first crucible and a second crucible, the first crucible having a bottom and a cylindrical shape, and the second crucible being disposed in an inside of the first crucible and having a bottom portion thereof provided with a communication hole communicating with the first crucible;

melting the raw material by heating the raw material melt-containing portion; and

growing a crystal by making a seed crystal be in contact with a surface of the raw material melt in a state covered with the encapsulating material and by pulling up the seed crystal,

wherein a crucible having a tapered structure in which an inner diameter of a bottom portion of the crucible is smaller than an inner diameter of a top portion of the crucible and in which a side face thereof tilted with respect to a vertical direction within a range of 0.2° to 10° , and a diameter of a communication hole may be not

more than 1/5 of the inner diameter of the crucible may be used as the second crucible, and

when the body of a crystal is grown, a heater temperature is controlled so that on an interface between a growing crystal and the raw material melt, the crystallization is advanced until reaching an inner wall of the second crucible, and the crystallization is done in such a way that a diameter of the body of the growing crystal is consistent with an inner diameter of the second crucible on the interface and the diameter of the body of the growing crystal is confined by the inner wall of the second crucible, while the crystal is grown by maintaining a surface of the growing crystal in a state covered with the encapsulating material until termination of crystal growth.

2. The method for producing a compound semiconductor single crystal as claimed in claim 1, wherein an amount of the encapsulating material to be added is set to an amount such that the encapsulating material is capable of filling a space generated between the growing crystal and the second crucible in accordance with the crystal growth and covering an entire surface of the growing crystal.

3. (Deleted)

4. (Deleted)

5. (Amended) The method for producing a compound semiconductor single crystal as claimed in claim 1 or claim 2, wherein the crystal growth is performed in a state of the second crucible being dipped in the raw material melt contained in the first crucible to a depth within a range of 10 mm to 40 mm.

6. (Deleted)

7. (Amended) The method for producing a compound semiconductor single crystal as claimed in any one of claims 1, 2, and 5, wherein a temperature gradient in the raw material melt is set to at least not more than 20°C/cm.